

S T U D I E S I N T H E L I G H T S E N S E

WITH SPECIAL REFERENCE TO CLINICAL

INVESTIGATION.

Being a Thesis for the Degree of
M.D. of Edinburgh University

by

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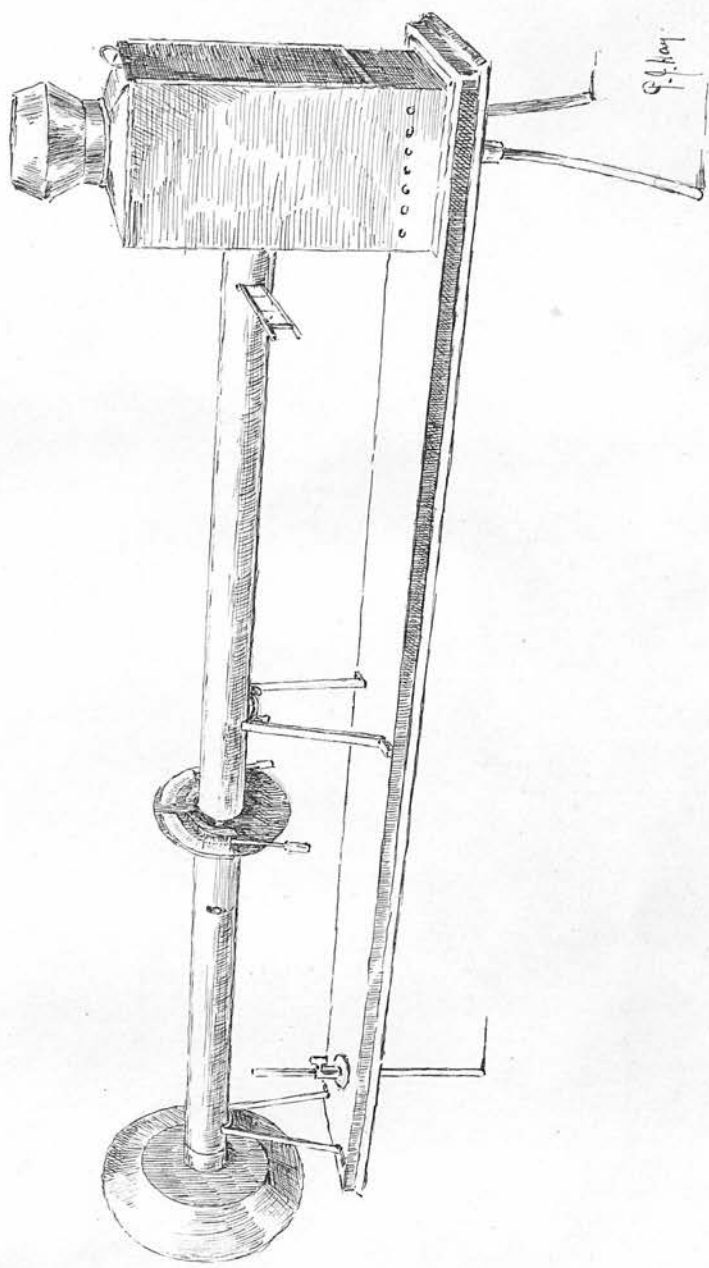


Fig. 1

S T U D I E S I N T H E L I G H T S E N S E

WITH SPECIAL REFERENCE TO CLINICAL INVESTIGATION.

"Obwohl man schon seit langer Zeit verschiedene Wege kennt, auf welchen man zu einem Numerischen Ausdruck, sowohl für den Lichtsinn, als für den Farbensinn gelangen kann, so fehlt doch noch viel daran, dass die eben genannten beiden Sinnesenergien so oft und so genau bestimmt würden als der Formsinn.*

Though more than 20 years have passed since these remarks were made, Ole Bull** would have been perfectly justified in using similar words to-day if he had purposed publishing a new series of studies in the light sense. On the other hand, the colour sense /

* "Although several methods have been known for a long time, by means of which one could arrive at numerical expression, both for the light sense and the colour sense, yet both of these functions are still far from being tested as frequently and as accurately as the form sense.

* Ole B. Bull, "Studien über den Lichtsinn und Farbensinn, Graefe's Archiv. f. Ophthalmologie, XXVII., 1, p.54.

sense has attracted a good deal of attention, both with regard to physiology as well as pathology.

That the former has not been examined more frequently may be said to be due chiefly to the fact that it is not possible to do so with the same comfort and ease as in the case of study of the form sense, and that at least up to the present, there has not been the same degree of fascination about it that belongs to the colour sense.

The first difficulty I have striven to minimise by designing a new photometer, and with regard to the second, it may be expected that the subject will gain in interest, both on its own merits, and in the light of its relations to the colour sense.

Before passing on to the subject proper of these pages, the clinical investigation, a few remarks may be permitted with reference to the physiology of the light sense.

Since the classical experiments of Bjerrun^{*} the examination of the sensibility of the retina to light has proceeded upon two lines, the one to arrive at the light minimum, M., the other to determine the light difference, D.. By light minimum is meant the/

* Jannik Bjerrun. "Untersuchungen über den Lichtsinn und Raumsinn bei verschiedenen Augenkrankheiten. Graefe's Archiv. f. Ophthalmologie, XXX., II., p.201.

the minimal stimulus capable of being perceived, the threshold of sensibility. In the use of colourless light there is only one such threshold. Coloured light, however, at low intensities, appears colourless, and therefore one has to distinguish between the point at which the coloured light is seen as light only, the absolute threshold, and the point at which its colour can be determined, the specific or chromatic threshold. The interval is called the photochromatic interval, and is greatest for green, nearly absent for red. The fact that the interval between the absolute and chromatic thresholds is greatest for green, stands in relation to Purkinje's phenomenon. Purkinje found that with decreasing intensity of the spectrum, the short wave end became relatively the brighter; and when a colourless spectrum is reached, the brightest part is then seen to be in the green. Under these conditions the light sense is most sensitive to waves corresponding to E.; at ordinary luminosities, however, waves corresponding to D. appear to make a greater impression. The maximum of sensation is reached with a lower intensity, in light of short wave lengths, than in that of long wave lengths. Blue/

Blue does not retain its specific tone as long as red. If the intensity is increased beyond ordinary limits, the whole spectrum becomes colourless. Thus there is an intimate relation between the light sense and colour sense, the former being alone affected in light of low and high intensities, while medium intensities affect both.

By light difference is meant the minimal difference capable of being perceived, the threshold of discrimination. For colourless light there is only one, but coloured light may be examined as regards tone, brightness and saturation. Aubert* states that, as the illumination diminishes, the threshold of discrimination is increased. Kräpelin** and Schirmer***, on the other hand, found that the threshold of discrimination is constant when due attention is paid to adaptation.

The light difference is stated to be $\frac{1}{186}$ (Aubert), $\frac{1}{217}$ Schirmer, $\frac{1}{240}$ (Ole Bull). It appears to me to be still less.

Whether/

* Aubert. "Physiologie der Netzhaut, p.52.

** Kräpelin, "Handbuch der physiol.Optic., 1867 p.315.

*** Schirmer, "Phil. Stud. II., p.316

Whether the light sense is equally good all over the retina seems to be still a moot point. According to the latest experiments (Krienes*) the fovea is supposed to be right-blind compared to the periphery of the retina.

Henry believes that the light minimum tends to increase after the age of 30.

The first to study the light sense to any extent in cases of disease was Förster**. His investigations were directed entirely towards the determination of the light-minimum, and for this purpose an apparatus was used, designed by himself and known as Forster's photometer (It was called a "Lichtsinnmesser" originally, a more accurate term.) This still seems to be the instrument chiefly used, where the light minimum is to be estimated. Briefly, it consists of a box into which the observer looks. On the wall facing him there are white letters upon a dark background, which may be illuminated more or less by means of a diaphragm regulating the amount of light from a standard candle.

The apparatus suffers from more defects than one but/

* Hans Krienes, "Der Lichtsinn bei Krankheiten der Retina, Choroidea und des Sehnerven." Archiv. f. Ophthalmologie, XXXIII.

** Foerster: "Lichtsinn bei Krankheiten d. Choroidea u. Retina." Zehender's klinische Monatsblätter für Augenheilkunde, 1871.

but still some interesting results were obtained. Assuming the standard of the normal light minimum to be $\frac{1}{1}$ then Förster found it ~~very~~ to be:

from $\frac{1}{1}$ to $\frac{1}{4}$	in Neuritis Optica.
$\frac{1}{12}$	" Retinitis apoplectica.
$\frac{1}{6}$	" Apoplexia retinae
from $\frac{1}{1}$ to $\frac{1}{2}$	" Retinitis albuminurica.
" $\frac{1}{1}$ to $\frac{1}{6}$	" Atrophia nervi optici (white)
$\frac{1}{6}$	" Hemiopia ex apoplexia cerebri.
$\frac{1}{1}$	" Amblyopia ex abusu nicot- ianae et spirituosorum.
from $\frac{1}{50}$ to $\frac{1}{225}$	in Choroideitis disseminata
" $\frac{1}{25}$ to $\frac{1}{750}$	in Retinitis pigmentosa
" $\frac{1}{56}$ to $\frac{1}{750}$	in Sublatio retinae
" $\frac{1}{64}$ to $\frac{1}{750}$	in Choroideitis syphilitica
" $\frac{1}{306}$ to $\frac{1}{750}$	in Atrophia nervi optici (yellow, secondary to syphilitic choroiditis)

Thus two great groups stood out in contrast, and, as Förster pointed out, the first consisted of diseases primarily involving the nervous elements; the second of those in which the choroid and external layers of the retina were implicated: and it was/

was in the latter that the light sense was found much reduced; or, in other words, the light minimum much increased.

A few years later, Bjerrum went a step further. Apparently up to that time one had been satisfied with ascertaining either the light minimum or the light difference, and had assumed that a diminution in the one meant a proportionate diminution in the other. Bjerrum, however, argued, "Man kann sich die Reizschwelle des Lichtsinns vergrößert denken ohne dass die Unterschiedsempfindlichkeit für einigermaßen bedeutende Helligkeiten verändert ist, - und man kann sich diese verkleinert denken ohne Veränderung der Reizschwelle."*

In order to determine at the same time the relationship between the visual acuity and light sense, the experiments were carried out with Snellen's test types, first with good daylight and then with varying degrees of illumination. The examination/

* Translation: One can imagine the light minimum to be increased, without any change in the light difference for somewhat considerable degrees of illumination; and one can imagine the latter increased without any change in the light minimum.

examination was repeated with similar test types of four different shades of grey. The patient was then allowed ten minutes to accustom himself to daylight again, and then he was examined with Mason's disc.

It was found that the light minimum may be considerably increased without any affection of the light difference for greater intensities, while on the other hand, the reverse is also true: the light difference may be much affected without any increase in the light minimum.

Patients with choroido-retinitis showed a tendency to an increase in the light minimum, whereas those suffering from optic atrophy showed an increase in the light difference.

Cases of Tobacco Amblyopia presented an increase in the light difference.

The visual acuity obtained with the grey letters was found to be a more delicate test for differences in illumination, than that obtained with black letters. For this reason, hemeralopia was detected sooner with the pale letters than with the black letters, when the illumination was reduced.

Medical

At the Eighth International Congress at Copenhagen/

hagen, Samelsohn read a paper on the light sense, in which he communicated the results of a long series of examinations with Mason's Disc. He ascertained that affections of a purely optical nature involving the cornea, lens or vitreous have no influence upon the light difference; but that refractive errors are not uncommonly associated with an increase in it, whether the error is corrected or not.

Low degrees of myopia do not seem to show any affection of D. (light difference) whereas, in errors of more than 3 diopters $2/3$ of the cases are affected.

Eyes with a high degree of hypermetropia are in a similar position; but not in such a marked degree.

Monocular strabismus shows an increase as a rule in the deviating eye. (Bjerrum did not detect any.)

All intraocular diseases of the eye seemed to be associated with an increase of D., optic atrophy most, and choroido-retinitis least. This is in accordance with the results of Bjerrum.

In Toxic Amblyopia, D. was normal if there was ~~no~~ absolute scotoma present, otherwise it was more or/

or less increased.

In Glaucoma, both the light minimum and the light difference were increased, though the latter was not so marked as in optic atrophy.

Further investigations were made by Henry*, who used a photometer in which opal discs were placed between the observer and a standard candle. He found in this way that the light minimum was markedly increased in diseases of the retina, but not so much in choroidal disease.

It is some years now since the last of these investigations was published, and since then nothing more has appeared on the subject of the light sense pure and simple. Further studies seemed to me to demand an apparatus more conveniently arranged, and yet delicate, besides being so constructed that it owed its properties to simple physical laws, so that an exact duplicate could be built. It seemed also desirable to be able to test the light minimum and the light difference, both with same instrument and under the same conditions.

It was during the summer of 1903 that it occurred to me, that the construction of such an instrument/

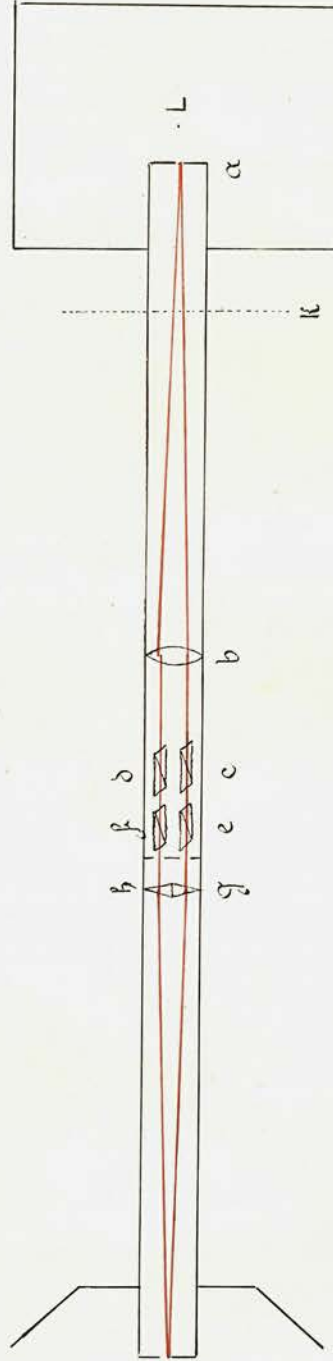
*R. Wallace Henry, Ophthalmic Review, Vol.XV., p.33.

ment should be feasible, and I spent many months in trying to find a satisfactory solution of the problem. It was found impossible to vary the intensity of the source of light itself in a practical way, and equally so to obstruct the path of light by means of standard opacities, either fluid or solid. It may perhaps be mentioned that opal discs such as are used in Henry's instrument are approximately standardised.

In the instrument described below and designed by myself, the rays of light are polarised, and their further course towards the observer is more or less permitted by means of an analyzer. Thus a very delicate instrument is obtained, in which the range of the light sense is divided into 900 parts, as will be explained. It can be rendered still more delicate by means of a device described below.

The source of light is the standard candle L. (see Scheme and sketch); the distance between it and the eye of the observer is one meter. A luminous point is obtained by means of a diaphragm (a), with an aperture of 1 mm. in diameter. The rays diverging from this point are rendered parallel by a lens (b), so placed that its focus coincides with/

Scheme of Optical Arrangement of Photometer.



L, Standard Candle.

a, Diaphragm.

b, Lens.

c, d, First Pair of Nicol Prisms.

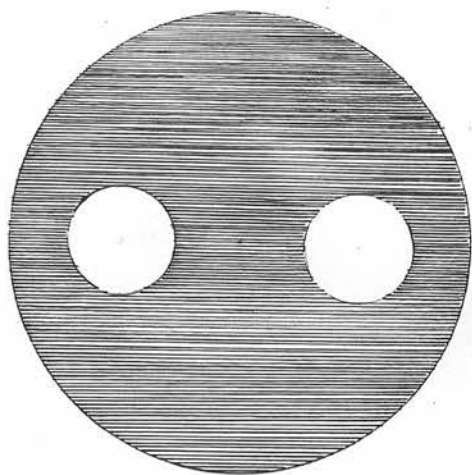
e, f, Second Pair of Nicol Prisms.

g, h, Reflecting Prisms.

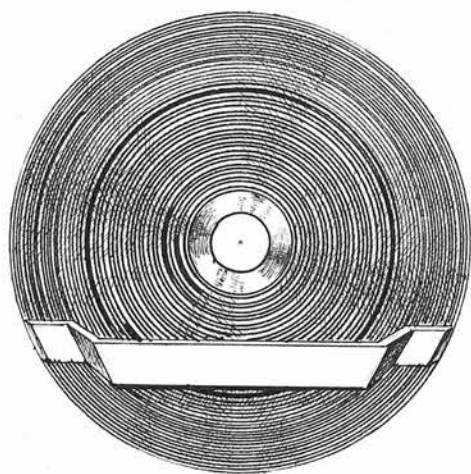
k, Diaphragm for Coloured Glasses.

P. May.

with the luminous point. They then pass through a Nicol prism (c) and in this way become polarised. For purposes of examining the light difference, two Nicol prisms are placed side by side, in such a way as to receive the same amount of light. The polarised light leaving the prisms (c) and (d) then falls upon a second pair of Nicol prisms (e) and (f). When the latter have the same position as regards plane of polarisation, as the former, they allow the light to pass through; if, however, the planes of polarisation are at right angles to each other, no light is transmitted. In the intermediate positions a certain amount is allowed to pass, which varies with the angle obtaining between the planes of polarisation. Thus all degrees from complete darkness to total light are obtained, and the standard of darkness is not an arbitrary, subjective one; but an absolute one, as we know it is physically impossible for any light to be transmitted. The light leaving the prisms (e) and (f) is deviated towards the aperture in the eye piece, by means of the ordinary prisms (g) and (h), so that for purposes of comparison both luminous areas can be viewed at the same time. Again, the standard of/



The two luminous areas or 'Lights' seen through the
Eye-piece of the Photometer.



P. J. May.

The Eye-piece of the Photometer.

of comparison is not a subjective, but an absolute one, since if the two analysing prisms are placed at the same angles, the same amount of light is transmitted through each of them. The luminous areas are rendered round by diaphragms placed in front of the Nicol prisms in order to avoid implicating the form sense.

The standard candle is placed in a light-tight box, and can be so raised and lowered, or moved from side to side, so as to be exactly opposite the aperture in the diaphragm.

The centre of the tube is adjustable, so that the instrument can be centred in the same way as an Abbé condensor in a microscope.

There are two scales on the apparatus, one for each aperture. Each is divided into 90 degrees. The prisms have to be turned through a right angle in order to vary the illumination from total light to complete darkness; the position of the prisms is shown by an indicator for each scale. If the indicator is standing at 90° , all the light from the candle is passing through (strictly speaking, this is not quite correct; but the assumption does not vitiate the results of the examinations). If the/

the indicator is standing at zero, no light is passing through. The prisms are turned by means of tangent-screws and the scales are read with the help of a Vernier, the latter dividing each degree into ten parts. The scales are thus divided into 900 parts

If the indicator is standing at Zero no light is passing through the prisms.

If the indicator is standing at 20° , 20° of the whole possible 90° of light are passing through

There still remains the test for colour-vision. For this purpose a slide (k) with coloured glasses is interposed between the source of light and the lens (L)

At the eye piece there is an arrangement for placing spherical and cylindrical lenses in front of the aperture if necessary, so that the rays of light can be focussed accurately upon the retina. On the other hand, supposing one wishes to test the general sensitiveness of the retina, this may be done by bringing the rays to a focus in front of the retina by means of a convex lens. By the same means the quantity of light reaching each rod and cone may be reduced and thus the apparatus rendered still more delicate.

The/

The end of the instrument next to the patient can be raised or lowered to a suitable height.

There is an advantage which is not to be despised in having a tube so that the patient can grasp the instrument like a telescope, and in this manner to obtain, with the help of his muscular sense, an idea in which direction to look.

The examination is undertaken in a dark room. The scales are read with the help of a little pocket electric lamp, such as can be obtained for a shilling or two, and any stray light is kept off the patient by a shield.

How to use the Photometer.

Before examining a patient, the light must be so adjusted that both prisms are illuminated equally. Both prisms are set at 10 degrees and then the light can be adjusted rapidly and accurately by vertical and lateral adjustment of the candle.

The patient is then asked to look through the instrument, and is asked to note the four following points:-

1. When one light begins to differ from the other in intensity.

2./

2. When the fainter of the two disappears.
3. When it reappears.
4. When it is equal to the other.

The movement of the prisms is noiseless, so that the patient cannot get any information as to whether their position has been changed or not.

I instituted these four tests, which to my knowledge have not been tried before, because it was noticed

(1) That most patients were slower in noting a difference in the intensities, and more accurate in equalising them;

(2) That they were slower in detecting the re-appearance of the light than its disappearance.

To give an example:

When a patient is going to be examined, both prisms are set so that 100 of light are allowed to pass through each of them. Thus the illumination of the two apertures seen in the photometer is equal. Then one of the prisms, say the one on the patient's right hand side, is so rotated as to diminish the quantity of light passing through it. The patient is watching the two illuminated apertures all the time and says when he notes the right aperture becoming/

coming fainter than the left; this may be at a point indicated as 7° . This is noted by the surgeon. The prism is then turned further towards zero (darkness) and the patient sees 6° , 5° , 4° , 3° , 2° , 1° , 0.5° and in point of fact he sees the last tenth of a degree and does not say "dark" until the pointer indicates zero. The patient is now told to watch the returning light. The prism, starting from zero, moves to 0.5° , 1° , 1.5° and it is perhaps only when 2° are indicated that the patient says he notices the first glimpse of light.

By light minimum is meant, where not stated otherwise, the least amount of the disappearing light the patient can observe.

For light difference the patient is asked to tell when he thinks both "lights" (as the patient calls the illuminated areas in the photometer) are equal, and then $\frac{1}{10}$ is noted below that,

e.g. $10=9$, therefore $D = 10-8.9$

The patient thought the two "lights" equal when the left prism stood at 10° and the right at 9, therefore they were different when the right one was still at 8.9.

Ten minutes are allowed for adaptation

↓ means diminishing light

↑ means increasing light,

The results obtained in the following pages were noted before any literature had been read on the subject, except Henry's article in the Ophthalmic Review. I think I may say they are free from bias.

The Emmetropic, Myopic and Hypermetropic Eye

Patients with emmetropic eyes, and those with low degrees of myopia and hypermetropia are able to detect from 0.1 to 0.3 degrees of light, the first nearly always noting 0.1°, the ages of the patients being from ten to thirty. Their light difference has a greater range, varying with the intelligence, education, and powers of observation of the patient. At 10° it may vary from 0.1 to 0.5, (10° is a moderate light intensity.)

The following instances may be given:-

J.W., age 29.

$$\text{R.V. } \frac{6}{8} \quad \text{c} + .50 = \frac{6}{6} \quad \text{R.M. 0.3., R.D. 10-10.3}$$

$$\text{L.V. } \frac{6}{8} \quad \text{c} + .50 = \frac{6}{6} \quad \text{L.M. 0.3, L.D. 10-10.3}$$

J.G./

J.G., age 30.

$$\begin{array}{llll} \text{R.V. } \frac{6}{6} \text{ } \hat{c} +.75 = \frac{6}{6} & \text{R.M. } 0.1 & \text{R.D. } 10-9.2 \\ \text{L.V. } \frac{6}{6} \text{ } \hat{c} +1 = \frac{6}{6} & \text{L.M. } 0.1 & \text{L.D. } 10-9.3 \end{array}$$

In patients with high refractive errors, the powers for noting differences in illumination especially, are much diminished, and sometimes the light minimum is affected. The four cases instanced below show these points well, but any other cases would have demonstrated them in the same way:

Examples of High Errors of Refraction:

1. Julia W., age 8., School.

$$\begin{array}{llll} \text{R.V. } \frac{6}{36} \text{ part } \hat{c} +7\text{C} +1 \text{ ax. } 80^{\circ}; & \text{R.M. } 0.1 & \downarrow & \uparrow \\ & & 1.0; & \uparrow \\ & & \text{R.D. } 10-4.6 \\ \text{L.V. } \frac{6}{18} \text{ part } \hat{c} +7\text{C} +1 \text{ ax. } 100^{\circ}; & \text{L.M. } 0.1, 1.0; & & \end{array}$$

2. Alfred P., age 13, School.

$$\begin{array}{llll} \text{R.V. } \frac{6}{18} \hat{c} +5.5\text{C} +2 \text{ ax. } 60^{\circ}; & \text{R.M. } 0.1, 2.8; & \downarrow & \uparrow \\ & & \text{R.D. } 10-5, & 10-7.4 \\ \text{L.V. } \frac{6}{12} \hat{c} +4.5\text{C} +2 \text{ ax. } 135^{\circ}; & \text{L.M. } 0.1, 2.0; & \text{L.D. } 10-7.8 & 10-7.5. \end{array}$$

3. Samuel C., age 25., Tailor.

$$\begin{array}{llll} \text{R.V. } \frac{6}{24} \hat{c} - 6\text{C} - 1 \text{ ax. } 180^{\circ} & \text{R.M. } 0.1, 2.5; & \downarrow & \uparrow \\ & & \text{R.D. } 10-4.3, & 10-7.3 \\ \text{L.V. } \frac{6}{18} \hat{c} - 6\text{C} - 1 \text{ ax. } 180^{\circ} & \text{L.M. } 0.1, 2.7; & \text{L.D. } 10-4.3, & 10-11.6 \end{array}$$

4. Samuel H., age 18, Crane Driver.

$$\begin{array}{llll} \text{R.V. } \frac{6}{12} \hat{c} - 3\text{C} - 3.5 \text{ ax. } 180^{\circ} & \text{R.M. } 1.0, 4.0; & \downarrow & \uparrow \\ & & \text{R.D. } 10-8.5, \\ \text{L.V. } \frac{6}{12} \hat{c} - 3\text{C} - 3.5 \text{ ax. } 180^{\circ}, & \text{L.M. } 1.0, 4.0; & \text{L.D. } 10-8.4 \end{array}$$

Foreign Bodies in the Globe:

The following three patients were examined some time after the removal of the foreign body (steel). They show the effect that vitreous opacities have upon the light sense. These opacities were present to a greater or lesser extent in each case. Fundus normal.

1. William J., age 29, Fitter.

R.V. handmovements, R.M. 4.0, R.D. 10-10.5

2. James R., age 34, Wheelwright

R.V. $\frac{6}{18}$, R.M., 8; R.D., 10-7.7

3. Walter T., age 32, Labourer.

R.V. Handmovements, R.M. 23.7. F.N.

In each case the light minimum is considerably increased, whereas the light difference is not affected to the same extent.

As regards the third patient, no estimate of the light difference could be obtained, because he had only a very diffuse impression of light, and could not make out whether only one, or both of the lighted areas were shown him. The large increase in the light minimum is all the more remarkable, because/

cause the vitreous opacities were so fine and evenly distributed that quite a fair view of the fundus could be obtained.

Choroiditis and Choroidal Atrophy:

Disseminated choroiditis and syphilitic choroiditis have been so well studied and their main characteristic, the increase of the light minimum, so well established that no further additions in this direction have seemed to me to be necessary.

Other varieties, therefore, were examined, varieties of which there were no records as regards the light sense, and in which the inflammatory condition was localised, and, as far as could be ascertained, not of a syphilitic nature. The results in these cases were not by any means uniform; sometimes the light minimum was more affected than the light difference; sometimes the opposite was the case.

Jane W. age 17, no occupation, presented a different appearance in each eye. The left eye was affected with typical disseminated choroiditis. L.V. was $\frac{6}{18}$ c +2, L.M. 6.5; L.D. 10-10.5.

It thus confirms previous observations. The right eye showed a localised patch of choroiditis, not involving/

involving the macula; R.V. $\frac{6}{12}$ c + 6D + 2 ax. 60°, R.M. 6.3; R.D. 10-18.5. Thus in this case both M. & D. were affected, and almost to the same extent, as something must be allowed for the high hypermetropia. It will be noticed that the girl allowed the right light in the photometer to be increased beyond 10.

The next patient offers a contrast. The right eye was healthy; the left one showed a localised patch of choroiditis below and internal to the disc.

Alexander R., age 35, Railway Servant.

R.V. $\frac{6}{18}$ c - 1.5D - 1.75 ax. 180 = $\frac{6}{6}$, R.M. 0.1, R.D. 10-9

The myopia accounts for D.

L.V. $\frac{6}{36}$ c - 1.75D - 1 ax. 180 = $\frac{6}{12}$ p, L.M. 0.1, L.D. 10-15.7

There is a considerable increase in D.

Elizabeth H., age 55, widow.

Choroiditis, chiefly in the left eye, with some vitreous opacities in the latter. The inflammation did not involve the macula. Low Hypermetropia.

R.V. $\frac{6}{18}$, R.M. 0.1, R.D. 10-11

L.V. $\frac{6}{36}$ L.M. 2.3, L.D. 10-7.4

Phoebe B., 21, Brazier.

Choroiditis close to macula in both eyes; the right with a round area of atrophy of choroid close to/

to macula. Emmetropic.

R.V. $\langle \frac{6}{60}$, R.M. 8.4, R.D. 10-12

L.V. $\langle \frac{6}{60}$ L.M. 4.8, L.D. 10-8

Here the light minimum is chiefly affected.

Eleven other cases of a similar nature were examined in the same way; most (6) showed an increase in the light minimum; three an increase about equal as regards the two tests; 2 an increase in the light difference.

Thus it is difficult to draw any conclusions; but the light minimum seems less affected, the further the inflamed area is from the yellow spot.

In none of the cases did the light difference remain unaffected.

Glaucoma:

The cases of Glaucoma, sub-acute and chronic, that were examined, were characterised by a slight increase, if any, in the light minimum; whereas there was a considerable increase in the light difference. It is noteworthy that this condition was also found where apparently as yet there were no symptoms or signs of glaucoma; but where the patient/

tient was undoubtedly suffering from glaucoma in the other eye.

The following is an instance:

Ann P., age 67, widow

The patient came with an attack of acute glaucoma, and a history of chronic glaucoma of some duration in the left eye. She had no perception of light. Iridectomy was performed, but vision did not return.

As soon as the patient was able, the other eye was examined, and the following condition found:-

R.V. $\frac{6}{8}$ (4 letters) R. Field full; Tension good. Media clear, no cupping of the disc.

On examining the light sense, R.M. 1.0; R.D. 10-16!

Susan H., age 54, gold polisher

This patient complained of her sight failing in both eyes and of pain lasting three months. She had photophobia and saw coloured rings round lamps, etc. Tension full in the right eye; tension in the left good. The right eye was also affected with a nearly mature cataract.

On examining the light sense, the right eye was found to have no central light perception, and only faint perception of light at the periphery.

The/

The left eye:

L.V. $\frac{6}{12}$ partly c - 1 sph = $\frac{6}{8p}$; L.M. 0.3, L.D. 10-19.7,
i.e. no affection of the light minimum, but a large
increase of the light difference.

Dinah S., age 70, Laundress

This patient presented a contracted field, a
deep cup and she could only count fingers at 3 in.
L.M. 0.5, L.D. ¹⁰⁻4.0

Four other cases presented similar appearances
and were tested with similar results.

Optic Atrophy;

The results of the cases examined with regard
to light minimum and difference in optic atrophy
are largely confirmatory of those obtained by Bjerrum
and Samelsohn, viz., that the light difference is
largely increased; but the light minimum is not
very much affected.

In many instances, however, the light minimum
is considerably increased, as will be seen from the
cases given below.

Joseph L., 39, Turner

This was a case of optic atrophy in both eyes.
R.V./

R.V. $\left\langle \frac{6}{60} \right\rangle$, R.M., 0.1, R.D. 10-9.5

L.V. $\left\langle \frac{6}{60} \right\rangle$, L.M. 6.0, L.D. 20-29.

Frank W., age 31, Ex-soldier

This patient was suffering from optic atrophy in both eyes, following upon malaria.

R.V. $\left\langle \frac{6}{60} \right\rangle$, R.M. 15.5; R.D. not obtainable

L.V. $\left\langle \frac{6}{60} \right\rangle$, L.M. 10.6; L.D. 20-31.8

William B., age 32, carter

Optic atrophy present in both eyes.

R.V. fingers at 70 cm. R.M. 1.0; R.D. 10-6.6

L.V. fingers at 30 cm. L.M. 6.0; L.D. 10-20.7

Tobacco Amblyopia:

Tobacco amblyopia does not seem to be associated with any marked affection of the light sense. Both the light minimum and the light difference are only slightly increased.

To show how far the light sense is affected, the two following cases are cited. They are taken from a series of ten similar cases:

Frank H., age 50, Porter

This patient was in the habit of smoking one ounce per diem of "Pioneer" or "Smith's Glasgow Mixture./

Mixture. Central Scotoma was present for all colours.

R.V. $\frac{6}{18}$, R.M. 0.3; R.D. 10-10.5
 L.V. $\frac{6}{60}$ L.M. 1.0; L.D. 10-8

James P., age 38, brass tube drawer.

This patient smoked half an ounce of twist per diem. Central scotoma was present for all colours.

R.V. $\frac{6}{60}$, R.M. 1.5; R.D. 10-9.5
 L.V. $\frac{6}{60}$, L.M. 1.0; L.D. 10-11.4

Retinitis:

That the light minimum is markedly increased was shown by Förster and has been confirmed by subsequent writers. The light difference is also very much increased.

Retinitis pigmentosa.

Charles H.C., age 44, No occupation:

This patient presented typical retinitis pigmentosa with secondary atrophy of the optic nerves. He had lost his perception of light in the right eye. The left one showed:-

L.M. 5.0; L.D. 10-20.

Diabetic Retinitis:

Alfred N., age 66, Music Teacher.

This/

This patient had been suffering from diabetes mellitus for more than twelve months. The right eye did not show any gross lesion in the fundus. The left one, however, showed extensive retinal haemorrhages, with retinitis, distributed irregularly over the fundus.

R.V. $\frac{6}{8}$; R.M., 0.3; R.D. 10-10.7

L.V. $\frac{6}{12}$; L.M., 0.8; L.D. 10-12.7

Thus the light sense was only slightly affected, especially the light minimum.

Retinitis proliferans:

Louisa Y., age 28, No occupation

Retinitis proliferans was present in the left eye. Both eyes were slightly myopic.

L.V. fingers at 3 feet.

L.V. $\frac{6}{60}$ c - 1 Cyl.ax.90°, L.M. 8, L.D. 10-15.5

Here both light minimum and light difference were markedly increased.

Albuminuritic Retinitis:

James H., age 45, Bricklayer:

Albuminuric retinitis was found in the right eye.

R.V. $\langle \frac{6}{60}$, R.M. 4.8; R.D. 10-14.2

Jesse W., age 50, Labourer

Albuminuric Retinitis was present in the right eye/.

eye.

R.V. Fingers at 2 m.; R.M. 7.2; R.D. 10-15.5

It is not easy to draw any conclusions from these cases of retinitis. It may be said, however, that inflammations of the retina do not all affect the light sense to the same extent, and that the deeper the inflammation, the greater the deterioration of the light sense.

SUMMARY OF THE AUTHOR'S RESULTS.

The results obtained with the new photometer may be summarised as follows:-

Refractive Errors, if low, do not affect the light sense; if high, ^{they} tend to increase the light difference.

Vitreous Opacities increase both the light minimum and the light difference.

Choroiditis, other than syphilitic and disseminated Choroiditis, affect both the light minimum and the light difference. The light minimum is generally more affected than the light difference; but not invariably so. The implication of the light sense seems to vary in extent according to the position of the lesion. It appears to be more impaired if the lesion is close to the macula.

Glaucoma chiefly increases the light difference. An increase in the light difference may be one of the earliest signs of the disease.

Optic Atrophy generally affects the light difference; but there are cases in which the light minimum is/

is very much increased.

Retinitis increases both the light minimum and the light difference. Affections involving the internal layers of the retina more than the external ones, do not seem to affect the light sense as much as those situated in the external layers.

In conclusion, I should like to say that the results obtained by me are not meant to be conclusive; but I think they tend to show that the examination of the light sense is important; that both the light minimum and the light difference should be examined in every case; that it is an advantage to be able to test the light minimum and the light difference under the same conditions; and that a delicate instrument is necessary.